Knowledge Management in an E-commerce System

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Abstract

There are a number of ways to conceptualize the activities of an e-commerce system. In this paper we consider the knowledge management aspects of e-commerce, and demonstrate that knowledge management is an essential part of the system's capabilities. Thereafter we present a detailed discussion of how the three main knowledge management functions (creation, transfer and application) take place in various parts of the system. Finally, we defend the claim that knowledge management is the base of adaptivity in an e-commerce environment.

Keywords Knowledge Management, Knowledge, Meta-knowledge, E-commerce System, Ontologies, Adaptivity

1. INTRODUCTION

Because of its immense and growing influence on all parts of the market and the commercial organizations within it, knowledge management has become of the primary focuses of management sciences [22]. As contrasted to other managed resources such as assets, capital and people, knowledge is characterized by perpetual regeneration: the more often knowledge is used, the more knowledge is produced. What is this knowledge? Researchers and practitioners involved in knowledge management usually conceptualize it as the highest level of reflection over the mass of available data. It is the end product of the transformation from data to information to knowledge. This process is the initial step of knowledge management, which is usually comprised of three main functions [2, 6, 11, 16, 29, 30, 31]:

1. **knowledge creation**, which encompasses the further sub-processes of acquisition, storage, validation, processing of new knowledge and integration with existing knowledge
2. **knowledge transfer**, which addresses the questions of how, what, when, to whom, in what form and to what purpose knowledge is delivered; and
3. **knowledge application**, which defines the mechanisms by which knowledge is employed.

These knowledge management functions create a continuous knowledge feedback loop: when existing knowledge is applied, a set of new possibilities for further knowledge creation materializes. When this knowledge is acquired, it must in turn be transferred in order for it to be applied again. This spiral process progresses through a series of incremental and continuous advances

The functions of knowledge management are carried out in various forms in both human- and Internet-based commercial organizations. Much of the execution of these functions is ingrained in the basic human mode of thought, and need not be consciously considered when making decisions – each day we create, transfer and apply knowledge in commerce without much awareness of it. In this paper we are interested in knowledge management as it materializes in e-commerce. In the electronic environment knowledge management is a synthesis of both economic and technical knowledge processes. Most theories of economic knowledge take for granted the medium of knowledge exchange –

human interaction. In e-commerce the primary medium of knowledge acquisition, exchange and application is the computer; this fundamental difference raises many issues in the translation of economic theories of knowledge to the domain of e-commerce. Here we wish to survey some of these issues, as well as speculate on some possible approaches to confronting them. Since e-commerce is a relatively new field, questions of how (or if it is possible) to translate the theoretical and practical experience of human-driven economies gained from years past into a form that is applicable in the e-commerce domain are still open. Before attempting to address a few of these questions, we will first look at some of the differences between e-commerce and traditional commerce in the context of knowledge management functions, in Section 2. The process of knowledge creation in the context of e-commerce will be summarized in Section 3. Typical knowledge acquisition techniques result in what we will name "low level knowledge", a form of knowledge that must be coerced into useful frameworks for particular knowledge consumers inside and outside the system. This process will be discussed in Sections 4 and 5. Finally, even though the processes of knowledge acquisition and knowledge transfer may seem difficult, that of knowledge application is considerably more so. We will address this application in Section 6.

2. COMMERCE VS. E-COMMERCE AND THE KNOWLEDGE PROCESSES

The translation of knowledge management functions from the domain of commerce to that of e-commerce is largely a process of explicating what is now implicit – an end-goal which has much in common to that of the classical approach to artificial intelligence, which seeks to comprehensively formalize human knowledge and knowledge of processes in order to replicate (or at least appear to replicate) human intelligence. The analogy to artificial intelligence extends further: one of the fundamental goals of e-commerce is to reproduce the (presumably positive) experiences of brick-and-mortar commerce – the helpful sales assistant, an easy-to-browse selection, etc. Obviously, not all aspects of commerce can be replicated in e-commerce. For the time being it is impossible to touch the sweater or to smell the perfumes, and so e-commerce must apply one of its most important strategies: *what cannot be replicated must be replaced.* Creating acceptable substitutes for these missing experiences is the key challenge for e-commerce, and the purpose of most of its "intelligent" processes. Knowledge management is the cornerstone of these processes, and the focal point of our contrast.

No doubt, the proper starting point for a broad comparison between electronic and brick-and-mortar commerce would be the most obvious one – the medium itself. However, in this paper we are solely interested in how the contrast between e-commerce and traditional business affects the knowledge management aspects of the e-commerce system, and how these differences introduce a widening gap in the way knowledge is managed in the human-based enterprise versus the electronic one. While a very large number of significant differences between commerce and e-commerce can be pointed to, we concentrate our attention on those that play an important role in the context of knowledge management. We divide them into three groups: differences of scope, differences for the customer and differences for the system.

2.1 Differences of scope

At the core of a contrast between electronic and traditional commerce lie some essential differences in the scope of operation, which have significant impact for knowledge management: the scope of commodities, the scope of time and the geographical scope of the market:

1. While conventional stores only carry a limited supply of items (typically the most popular), online stores can offer an almost unlimited number of goods, including specialty products targeted for a relatively small niche market. Confederations of electronic merchants (e.g. amazon.com, which is billed as having "Earth's Biggest Selection") acting as intermediaries between multiple sellers and customers, may generate a very large commodity search space [14, 33]. Moreover, assuming the growth of the online market continues, one may envision an intermediary system that uses the complete Internet as the source of its commodities, thus making its commodity space almost as large as the space of all commodities possibly available on Earth. It is easy to see that this has an immediate effect on the knowledge-related requirements in the system. For instance, while it is possible that in a small store few salespeople can know most of what it is to know about the offered commodities, a large e-commerce enterprise must store and manage an enormous amount of data about the available commodities – even if the accumulated data about each item is minimal, the shear number of items makes the total amount of data very large.

2. Keeping a physical store open 24 hours a day is expensive proportional to the amount of revenue it generates. An e-commerce system, on the other hand, can run non-stop with very little extra overhead. However, however, this requires the process of knowledge management to be an uninterrupted one. In standard commerce it is possible to execute and incorporate the results of knowledge management functions while the "system" is offline / the stores are closed, but this is not the case with an e-commerce system. It is even possible to envision a situation in which there is no slower time at night, because the store is online and customers are active all over the world.
3. Physical commerce is usually concerned with selling goods locally; even the largest multi-national are acclimated to fit the regions in which they operate. A successful electronic enterprise will, sooner or later, reach a truly global scale, and be forced to accommodate local differences in order to succeed in diverse markets. Because of this the amount of knowledge that the system must manage increases considerably, as knowledge about all local, cultural peculiarities must also be maintained. In addition, the overall picture of knowledge management functions becomes a bit fuzzier in certain situations: for example, a European businessman working in US may log in late at night to an operational center in Japan (where it is already the next day), to order goods to be delivered to Europe (where it is morning) to his family. In such a situation, knowledge acquisition functions become more complicated due to the fact that the customer, the "store" and the recipient(s) are different and reside in different countries and time zones (this may, for instance, make the conceptualization of knowledge acquisition more difficult).

2.2 Differences for the user

As is obvious to anyone who has purchased online, the user's experience of e-commerce is paradigmatically different than that of traditional commerce. Some of these differences are very closely related to those discussed above, while others are tied to the nature of computer-human interaction.

1. Customers of traditional stores live primarily in the vicinity of the store, visit it during normal hours of operation, purchase items from a limited selection of the most in-demand commodities in a given area (e.g. kosher food in New York, car battery heaters in Fairbanks) and are attached to a particular regularly visited store. As argued above, this is not the case in e-commerce "stores". Here customers can come from any place in the world. They are attached to a brand name of "store" (such as Amazon.com), not a physical location, they are served 24/7/365 and they expect to find anything that they are looking for. The knowledge management related effects of these requirements have been described above.
2. One of the more important differences that affects the customer behavior is the presence or lack of a human salesperson [3, 28]. To be able to overcome this difference a number of knowledge based personalization techniques have been and are being developed [12, 20, 25, 26, 34]. For further discussion of personalization and relationships with the customer, see [10].
3. Clients expect that their experience of an online store will be in line with the best of an ″Internet experience," one in which instant gratification is the mode – instead of searching across a monster size Walmart, where almost everything can be found, but it is unclear where it is hiding. We need to remember that in an Internet store it is easy to provide the potential customer with very detailed information about product(s) and service(s), as well as reference the large amount of additional information available in a multitude of other, Internet-based, repositories. This deluge of information, while crucial to overcoming the deficiencies of the system (e.g. lack of physical contact with the commodities) can also overwhelm the customer. This indicates clearly that a number of important techniques based on knowledge management should be applied in order to filter the information into an easily-comprehendible package. Most of these techniques are related to the general concept of personalization as information filtering: selection of the right sales support strategy, right interface, right search support etc.
4. There is still the problem of content delivery: customers who do not access the Internet through a fast enough connection to be able to receive high quality information. This limitation is especially important when we move from e-commerce to mobile commerce (m-commerce) and from high quality computer displays to PDA/cell phone displays that can deliver only low quality graphics, or no graphics at all. We must be able to actively apply knowledge about the physical and processing capabilities of display devices in order to regulate the form as well as the content of the information delivered to the contents.
5. Clients expect to feel and remain anonymous but also to be able to browse and purchase what they are really interested in, two inclinations that are often mutually incompatible in a traditional shopping scenario. In an

e-commerce system this is more feasible, but in order to do it the knowledge management processes must be made as transparent as possible, so that we may offer the improved service that accompanies increased knowledge of the target market without scaring the customer by acting like a "big brother" (also see discussion of personalization in [10]).

6. In customer-oriented business we are interested not only in what the customer has purchased, but also why she purchased it, as this knowledge is incredibly useful in "personalizing" the user's online shopping experience and suggesting related products. This situation is usually only possible in very small regional stores, in which the owner knows most of the customers and can readily learn or deduce the reasons for a particular purchase (if a couple is buying a new washer because they are expecting a baby, the store owner can suggest a number of additional products that should be purchased as well). This capability is not apparent in large chain stores. While it is possible that a skilled salesperson can learn something in conversations with the customer, these contacts are usually not enough. On the large scale it is only through extensive knowledge that we may attempt to make educated guesses as to why a purchase decision has been made. Also, because the user is identified to the system (e.g. by a login name) all of his actions may be related, versus the disconnected and mostly anonymous nature of real-life transactions. While this is a very positive development, it poses an important challenge to knowledge management, as the correct knowledge about each customer has to be acquired to provide her with the small store feeling (see [21]).

2.3 Differences for the system

Finally, we have to address the differences between commerce and e-commerce that occur inside of the system (here the system is understood very broadly and means any regular commercial entity or any e-commerce system).

1. There exist a number of techniques and tools that were developed to help manage knowledge in traditional enterprises, in which knowledge embodied in workers is the primary focus [32]. In the human enterprise we are particularly interested in extracting this knowledge, and the process of exchange of information between knowledge bearers. In e-commerce we have a much different situation, because most knowledge management occurs "inside" the IT infrastructure and therefore the human factor is minimal. This makes knowledge management difficult, as all of it has to happen in an almost-automatic fashion. At the same time, due to the lack of human involvement, one of the more important problems of knowledge management systems (human- and paper-based as well as electronic), the problem of knowledge sharing, does not exist (computers do not mind sharing knowledge with other computers).
2. Automatic recording of data related to the functioning of the e-commerce system is easily available; no traditional system has such stores of data readily available. It should be obvious that this collected data will become the crucial input to the knowledge management process, once it is transformed into information and then into knowledge.
3. The need for inventory management is different. While new approaches are starting to take effect among large chain retailers, typically what is "visible" to the customer is what available and it is "impossible" to oversell. In electronic commerce, if a large number of transactions occur simultaneously, special care must be taken to only sell goods that are available. On the other hand, since information about the inventory levels is constantly available sales strategies may be dynamically adjusted. This leads us back to knowledge management. Knowledge employed in inventory management is directly related to knowledge-driven sale strategies, knowledge used in commodity searches, negotiations with suppliers of a given commodity etc.
4. Finally, e-commerce systems are characterized by an almost unlimited and immediately accessible data about products and services. Therefore an important task of knowledge management is the ability to cope with large and continuous flow of information.

3. KNOWLEDGE CREATION: INFORMATION INTO KNOWLEDGE

Knowledge management experts describe knowledge creation as the continuous process of transforming tacit knowledge into explicit knowledge, that which can be expressed with a formal representation [5, 31]. This definition usually refers to knowledge acquisition from human experts. On a large scale, the difficulty of gathering knowledge from experts (often referred to as the bottleneck of the knowledge system) has necessitated the use of alternative, less troublesome sources of

knowledge. As the amount of data stored in local databases and other electronic repositories continues to increase, techniques for transforming this data into information and then knowledge become more important. The use of these techniques requires much less human input than traditional expert knowledge extraction. In the ideal situation, the experts are given only the task of verifying the generated knowledge and controlling the acquisition process. In our approach we will follow the general structure of knowledge management function, which consists of knowledge creation, transfer and storage, and application. We will therefore start from discussing the sources of data that is transformed into information and then into knowledge (while this is a mental shortcut, we will name these data sources: *sources of knowledge*). Overall, in the context of an e-commerce system we consider three primary sources of knowledge: users of the system, environment, and experts. We will now address each of these sources in some detail and follow with a brief overview of knowledge acquisition techniques and mechanisms.

3.1 Users of the system

Because the process of gathering data from sources within the e-commerce system can be automated and operate continuously, various types of electronic data are the most relied-upon original sources of knowledge for the system. These include the more transparent data sources related to customers such originating IP logs, cookies stored across sessions and verbose information logs generated by the system during interaction with users (which incorporate information about actions, as well as non-actions of the client; the fact that the user did not select a given pop-up-banner-ad may be as important as the fact that she has selected a given photo camera). In addition, there are several direct methods of extracting information from the user, such as questionnaires [9, 21]. From this information about the customer knowledge can also be extracted about individual and group behavior, about customs, inclination, etc. We also need to take into account that the system is an intermediary between suppliers and customers. In this way one can argue that while to relationship is not completely symmetric, suppliers constitute an additional group of users of the system. Making this, slightly controversial assumption, we can conceptualize data collected about suppliers in a similar way to that of the data collected from the customers. Here the data concerns the negotiation processes (auctions), commodity characteristics (prices, amounts, time), data about the quality of delivered commodities (obtained from customers and matched with suppliers), number of product returns, reaction time to our requests etc. From this data we gather the knowledge how to conduct the negotiation, with whom, on what conditions, which products to eliminate or incorporate.

3.2 The environment

While the customers and the suppliers are definitively part of the environment that the system operates in (see [9] for more details), we have separated them due to the fact that they provide a very specific and immediately applicable type of knowledge about the suppliers to the system and the customers (including potential customers) of the system itself. The environment is the world in which the customers and the suppliers and the system operate and that influences their actions. This influence goes directly to the suppliers and customers and is mediated through them as it influences the system. In the ideal situation the system should be able to consider all factors that influence the customers and their interactions with the system. The typical examples of such factors are: economic policy, new technology, fashion trends, cultural events, weather, etc. While easy to see that these factors can have an important influence on the e-commerce system, due to their generality they are the most difficult to pinpoint and to build knowledge about them through automatic knowledge acquisition processes.

3.3 Experts

Though knowledge acquisition from human experts may be a very difficult task, some knowledge may be gained in no other fashion. Expert knowledge is first extracted (using standard techniques) as the basis for the system's knowledge – a foundation of human experience-derived assumptions, which the system's knowledge can grow and evolve upon. As the system uses this knowledge to learn and expand, the experts are still needed to deal with atypical situations, statistical outliers, which the automated knowledge techniques have difficulty integrating into the system. The task of the system in these situations is to provide the human expert with enough information to help reaching a correct decision in as easy as possible way. In the next stage this, more intuitive, knowledge is incorporated into the system.

3.4 Knowledge acquisition techniques and methods

Knowledge acquisition from the data stored in the system applies primarily to the data collected from/about the customers and the environment (as seen above, knowledge acquisition from experts is achieved in a different, more direct, way). Techniques for knowledge acquisition from electronic data/information sources has been studied for some time and some significant advances have been already made. The general name for the processes that extract knowledge from electronic sources is knowledge discovery from databases (see also [7, 13, 15, 17, 27]).

As it was stressed in the Introduction, knowledge management is a continuous process of knowledge acquisition, transfer and application, where by applying knowledge new knowledge can be acquired again. Therefore, it is the learning process that results from interactions between the system and the three data sources described above that is one of the more important sources of knowledge in the system. This process mimics that of real organizations in the world economy, in which knowledge is acquired, not through a single act, but through a continuous process of improvement on knowledge gained thus far. In order to meet the requirements of a dynamically and often unpredictably changing world, knowledge acquisition must involve both knowledge adaptation and knowledge evolution.

Knowledge adaptation involves addition of new knowledge to that already existing, the creation of entirely new knowledge, the deprecation of irrelevant knowledge and the deletion of dead knowledge. Knowledge acquired from the knowledge may be relatively constant or especially liquid, because it often concerns trends in human behavior, which range from basic social tendencies to current fads. All of this knowledge must be correlated and evaluated according to how much it adds to the system's existing body of knowledge as well as other factors such as time dependency. Similarly, knowledge, which has ceased to be useful to the system, especially because it has become outdated, must be deprecated and removed from the system. This includes time-dependent events as well as models and techniques the system employs in business that have been superseded by better ones. In e-commerce systems adaptation is not a homogenous process. There are at least two types of adaptation: on-line and offline. The first occurs while the customer is online and the system is assisting him, while the latter is a complex process that integrates and analyzes all of the information collected by the system that may influence system knowledge. In this case the process of knowledge adaptation of inseparable from that of knowledge evolution. This refers to the process of applying trend analysis in an attempt to answer the questions: what is changing? how frequent does a change take place? This time dependent analysis gives us insight into knowledge evolution in the environment and in the e-commerce system. To be able to conduct such analysis it is necessary to collect historical data about the e-commerce system.

4. HIGHER-LEVEL-KNOWLEDGE: GENERAL CONSIDERATIONS

At this point we assume that there exists a layer of low-level knowledge acquired from the sources described above and residing in the knowledge base, which is divided into source areas (user behavior, human experts, news, etc.). While this low-level knowledge may be interesting in itself, it is not especially useful for e-commerce. In order for the system to take advantage of knowledge from disparate sources it must group these knowledge building blocks into a functional framework. In fact, there are many such frameworks existing in the system at the same time, each a different view on a subset of the system's knowledge. The existence of a variety of knowledge frameworks closely parallels knowledge roles in human organization, in which no one knowledge bearer is responsible for all of the functions of the organization, and thus each only requires a subset of the organization's knowledge. In fact, beyond the small scale it is impossible for any entity to possess more than a subset of the total knowledge. It is the union of these subsets, embodied in the form of "components" (human, electronic or other knowledge-bearing mediums) possessing knowledge that defines the organization. Of course there is an inherent overlap between knowledge blocks used by various components. Different uses of the same knowledge lead to the further refinement of that knowledge, as general knowledge splits into more specialized parts. This pattern of generalization to specialization creates a highly relevant web-like structure of low-level knowledge within the system. More precisely, there may be many such structures built out of low-level knowledge, e.g. various departments require different knowledge to fulfill their goals. Observe also, that knowledge that is very important to one group may be less important to the other; this does not change the knowledge in itself, but only the role it plays in the knowledge framework build to support actions of a given group.

As the different people / departments in a traditional commerce organization have different roles and employ the organization's knowledge in different fashions / from different perspectives, so too does the e-commerce system contain a variety of components, each of which requires access to a subset of the system's knowledge and has a "perspective" on that subset. For example, the components driving the user interface to the system are primarily concerned with knowledge that affects how users interact with the system. This includes knowledge of human sensory psychology and interface "usability" as well as the limits of the technologies used for displaying the interface (such as the web). All of this knowledge is low-level, acquired from human experts and system learning as described above. It is the perspective of the user interface components, which groups the otherwise disparate low-level knowledge into a framework useful for driving the user interface.

This perspective-framework is referred to as an *ontology*. While this term has a traditional philosophical meaning of the "study of being", in the world of the Internet it refers to a formalized medium of representing knowledge. The basic structure employed here has its origins in the frame-based representation described by Marvin Minsky [18]. In essence, a *frame* is a subset of knowledge, which is used by an "actor" to conceptualize the situation. A frame may contain sub-frames, which are other perspectives subsumed by the greater picture.

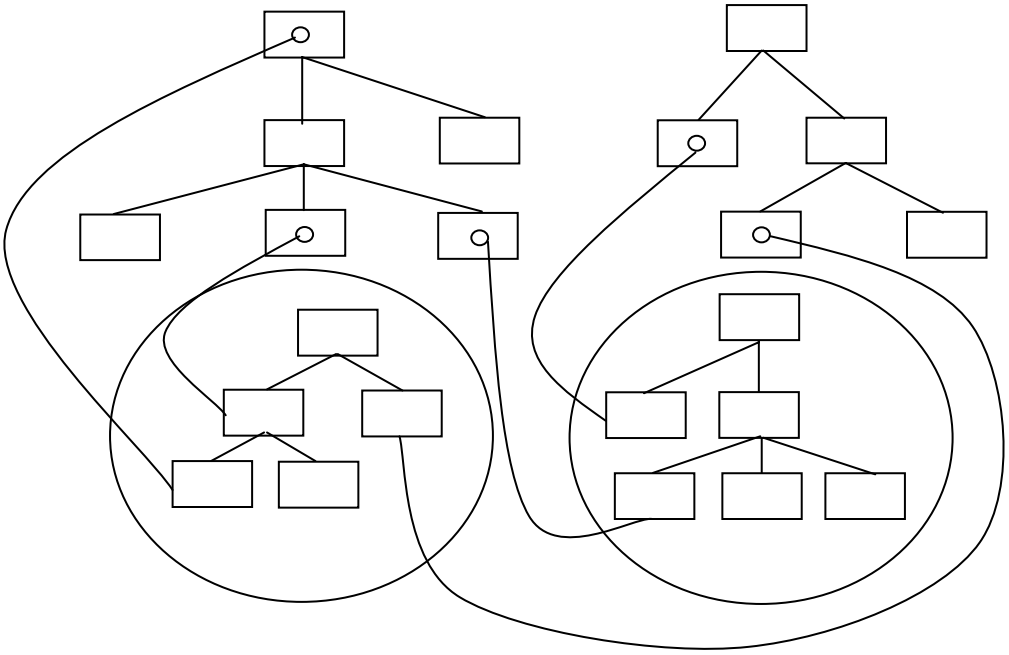

Figure 1. Perspectives on low-level knowledge in the system

This idea extends naturally into the domain of e-commerce, where ontology is a way of structuring the electronic reality that an e-commerce system has to deal with. Since various functional units have to achieve individual goals, each will need its own ontology. As an example we may consider the user interface components that require ontology of interface-related knowledge. Each component within this set of user interface components may have a smaller ontology that refers to the specific domain of action of that component. Thus the component ontologies are subsumed by the larger ontology needed by user interfaces, which ontology is subsumed by that pertinent to e-commerce customer support, which in turn is encompassed by the ontology for the system itself, which refers to all knowledge available to the system and how it is interrelated to each other. Realistically, such a total ontology may not exist, even for such a limited domain as e-commerce [8]. Practical considerations aside, many in the field of ontologies and semantic processing are currently attempting to define even larger ontologies, for describing the entirety of human-recognized reality [4]. In Figure 1 we illustrate the situation where two low level ontologies are utilized by two higher-level ontologies. Nodes in the ontology

with small circles denote pointers to low-level knowledge in the system, while the remaining nodes signify abstract structures within the ontology which clarify the relations between the pointed-to knowledge.

It must be emphasized that the variety of ontologies for structuring knowledge in the system does not change the underlying knowledge itself. The characteristics of a chair do not change just because we call it something other than a chair, or view it from the side or hanging from the ceiling. Similarly, the knowledge that a rare commodity in great demand will cost more does not change, regardless of whether it is the advertising engine or the inventory manager making use of this knowledge. However, the feedback loop of the knowledge management system does allow for this possibility, regardless of how static the knowledge may appear to be (see discussion below).

There are a huge number of possible ontologies within the e-commerce system, some of them designed for functional roles (such as driving the user interface) and others defined to provide a high-level overview of the system. These latter ontologies/perspectives are of particular interest to us as researchers, as they allow us to observe and manipulate the knowledge in the system, keeping in mind that even at the greatest level of abstraction these perspectives still refer to the low-level knowledge gained from experts, user interactions, etc., and can, if necessary, be concretized to knowledge actually represented in the knowledge base.

Finally, let us address the question of meta-knowledge. Its standard definition is "knowledge about knowledge." Observe first, that ontologies can already be considered examples of meta-knowledge, because they organize knowledge and thus represent knowledge about knowledge. Since ontologies can contain ontologies, we are dealing with a hierarchical structure, where each higher level represents a reflection about knowledge occurring on lover levels. In this way our system does not support a standard division of knowledge into knowledge and meta-knowledge, but rather a relational web of knowledge that represents the system's view of the reality it is immersed in.

5. KNOWLEDGE STRUCTURE: PERSPECTIVES

So far we have introduced the sources and techniques of acquisition of low-level knowledge. We have also discussed the idea of applying ontologies to impose useful relations on the building blocks of low-level knowledge and argued that there are multiple perspectives/ontologies on knowledge that will co-exist in the system. Let us now look at some of the more important of these perspectives, divided into two categories: five that are most relevant to human analysts, and three that are particularly useful for implementation of the system.

5.1 Empirical-model-situation knowledge structure

This ontology considers three types of knowledge within the system: empirical knowledge, model knowledge and situational knowledge. It is based on how knowledge is applied by humans in ordinary situations. As humans we possess empirical knowledge (such as the natural laws, and also what is referred to as "common sense" but is not all that common), which is the foundation of our models for viewing the world. These models, in order to be applicable to everyday situations, must be concretized by the details of the situations. The same approach to understanding the utilization of knowledge within the e-commerce system, while heavily abstracted from the actual implementation of the system, allows us to understand the knowledge management processes from a human perspective, and in many situations compare and adapt the actions and reactions of human commercial organizations to that of e-commerce systems. Let us consider each level of knowledge approached from this perspective in some detail.

5.1.1 Empirical knowledge

Empirical knowledge of the world is the most general and most fundamental type of knowledge, and it remains relatively constant throughout changing models and situations. At the core of this knowledge are the statements, principles and rules describing economic phenomena, which are central to the operation of any market player. Of course, this knowledge is available to all players, though it is rarely stated explicitly but is mostly present in the common cultural knowledge of human organizations. Examples of empirical knowledge include the laws of supply and demand, price curves, basic market models and strategies, etc. These rules are much too general to build competitive sales strategies, negotiate prices with suppliers, or otherwise refine the system, but merely allow the system to operate in the marketplace.

5.1.2 Model knowledge

This knowledge concerns the models that govern our approach to commerce. These models evolve over time, albeit in as stable a progression as possible given the dynamics of e-commerce. As the system operates and interacts with users, suppliers and the environment the general e-commerce models we have formulated are refined until they are specific enough to branch in to different models, which may be applied in different situations according to different cues. Knowledge of these cues and when/how to apply the various customer, supply, etc. models to various situations is a further abstraction of this model knowledge. Multiplicity of models results from generally accepted principle that there is not single model for any single complex problem (see for example [19]). We can consider for example model of sale strategy that can be enriched by adding or removing some of its properties. Knowledge from this level, when allows the system to achieve its determined goals may be sometimes used to modify the empirical knowledge (become one of the principles guiding the system). Roughly speaking knowledge on this level refers, for example, to different customer behavior groups according to their reaction to showed commodities advertisement.

5.1.3 Situational knowledge

Empirical and model knowledge are not enough for the system to act and react in a real situation, with real customers, real suppliers and a real environment in which the system is making (or losing!) money. For this we require specific situational knowledge. This knowledge is the lowest level of abstraction over the low-level knowledge gained from the various sources, though it is high enough that we can analyze its play in the abstracted mechanisms of the system without reducing the situational knowledge to its constituent parts. This fast-changing, situational knowledge is often valid only in a given time frame and sometimes only once (e.g. during a session with a customer). Because the e-commerce system is customer-driven, most of these situations concern a single customer, though the knowledge is not always limited to that customer's time-limited session but may span across sessions; here there is a problem in distinguishing which situational knowledge is applicable only once and which can be applied multiple times.

In fact, this knowledge is merely the "filling" for the model knowledge, which describes our general approach to the client. If our business/customer model proscribes a certain approach (e.g. especially obtrusive advertising), then the situational knowledge for accomplishing this model-defined objective will never come into play. At a certain distance from both the situational and model knowledge effects on the interaction with the customer is empirical knowledge, which casts a more subtle but nevertheless significant influence on the delivery of the system to the customer. We will not advertise an item which we do not have access to a stock of, or an item that doesn't exist. World knowledge places these constraints on our model knowledge, so that these possibilities never enter the picture of how the system functions. Here we must recognize that though the world knowledge constrains the model knowledge which itself constraints the situational knowledge, the latter are not subsets of the former, and in fact, the relationship between them (or any knowledge) cannot be described by sets or even object hierarchies. The relationships are cascading cause and effect. In addition, there is a feedback loop between all three, which allows situational or model knowledge to affect world knowledge, situational to affect model, etc. though this loop is highly restrained to prevent time- or other context-dependent variables from affecting more constant factors.

5.2 Economic

From this perspective, the e-commerce system may be considered solely as a market entity. The ontology of this view describes the range of economic laws and theories as well as practical models of enterprise organization, specifically applied to the e-commerce domain. Like any other economic entity, the e-commerce system has income, cost, profits as well as economic strategies. This is the perspective of the economist, and may be used to analyze in relation to other market players, traditional or electronic.

5.3 Personalization

The knowledge management processes of an e-commerce system and the knowledge that they operate on may be seen as an engine for personalization of user content. Some of the motivations and mechanisms for reaching this end through the use of knowledge have been described previously; in earlier works [10, 23, 24] we describe some specific means toward

this. In general, the main goal of content personalization, as viewed from the e-commerce perspective, is to support the client-system interactions and provide a quality substitute for the missing human salesperson. In particular, through personalization the system aims at: providing a better quality of buying experience through understanding and predicting needs of individual customers, improvement of satisfaction of the customer, improved effectiveness of the system (as measured through the total number of items sold to each client), building of a brand recognition and a relationship between clients and e-stores, that will result in customer returning and making additional purchases of commodities. Being able to directly interact with the client and track all of the interactions (see Section 2), allows the system to get to know the client and to adjust the offer to her expectations. In addition it allows the system to influence her choices as well as promote new products. An ontology designed for personalization combines knowledge about products and associated sale strategies combined with knowledge of the customer in order to make relevant suggestions. In addition, general knowledge about products combined with the analysis of market trends and client clustering allows the system to achieve success in dealing with new clients. Summarizing, the personalization engine perspective incorporates knowledge of users (described terms of populations, clusters and individuals), sale strategies as well as supply dynamics.

5.4 Organizational

In our earlier work analyzing abstractions of a real e-commerce system, we divided the functions of the system into supply support (SS) and customer support (CS) subsystems, which interact via a communication channel [9]. The knowledge management of the system may be viewed similarly: the knowledge utilized by the supply subsystem is largely system knowledge, required for the support of transaction management (buying and selling) and commodity management (selection, delivery and inventory). The customer subsystem, on the other hand, mimics the role of a human seller, supporting the customer in searching, selecting and purchasing merchandise [9]. These subsystems are largely analogous to those found in well-established human organizations: production and development on one side and marketing and customer relations on the other.

While knowledge about suppliers is mostly localized in the SS subsystem and knowledge about customers is in the CS subsystem, the two spheres are interdependent. The success of any form of commerce lies in the reconciliation of customer interests with business objectives, and e-commerce is no different in this sense. Consider that one of the goals of the supply system is to sell the commodity it has the most of (in order to reduce inventory) as well as the products that are most profitable. This knowledge of products must be transferred to the CS subsystem so that these products can be promoted, particularly to a target base of customers who are more likely to purchase them. On the other hand, the supply system must constantly accept feedback from the customer support system, in order to match the supply of a product to its demand. Similarly, a customer may have individual desires, which are not satisfied by a general selection of commodities, and these must also be taken into account by the supply system. Knowledge of this customer and his expectations are crucial to both the CS and SS subsystems – "the customer is always right" still applies to e-commerce, and in fact it is even more important because of the customer's additional expectations. Finally, knowledge of the outside world is pertinent to both subsystems: the system must function realistically (as described above) as well as follow trends and other information that is not mediated through the customer and supply sides. An ontology for the CS-SS models encompasses knowledge from human management experts, product planners and supply-side coordinators as well as that from customers relations specialists. It also includes knowledge describing the internal processes of successful organizations, from and upon which the system may adapt and grow through its continual operation in the market.

5.5 Customer support strategies

This ontology subsumes that of personalization, and references the entirety of knowledge necessary for serving customers. Thus there is some overlap with the economic, organizational and multiple other ontologies that relate to knowledge of customer support. Here the e-commerce system is perceived as a means to the end of customer satisfaction – "the customer is always right" – and we consider many qualifications for this, for instance:

- interaction with the system (easy to use, aesthetically pleasing),
- range of commodities offered,
- quality of service – timeliness, returns, responsiveness to feedback, etc.,

- guarantees of customer privacy,
- convenient forms of payment,
- the system's behavior when a product is out of stock,

as well as other service-oriented aspects, while still keeping in mind the profit goals of the enterprise. Thus the strategy of this perspective is "sell what you can to anyone you can." It is impossible to *only* address customer needs and expectations; the business perspective has to be taken into account as well. Customer support strategies have to strike a balance between the goals of the system and the customer.

5.6 Knowledge spaces

This implementation-level ontology categorizes knowledge created from information sources and human experts into knowledge about users, knowledge about the system and knowledge about the environment in which the system resides. These are spheres of knowledge, knowledge spaces, and are closely related to and structured according to the original sources, which the referred-to knowledge is acquired from. Knowledge created from interactions with users falls in to the user sphere, while knowledge concerning the system's operation as an enterprise (including supply support) resides in the system sphere. Knowledge derived from the outside world is in the environment sphere. Knowledge about users is fairly easy to define (though not so easy to gather): who the users are, what they like and dislike, how they employ the system, etc. Knowledge about the system is much broader, and includes knowledge of: current and potential products offered by the system, suppliers of those products, the system's business models and operating parameters and other categories related to the e-commerce system's role in the environment. Knowledge in the environment is everything that is external to the system, but must still be known to it; the system does not exist in a void, and if it is to succeed it must be "aware" of what of the world in which it operates. This requires knowledge of the theoretical (such as the basic laws of economy) to the practical (network outages).

The knowledge space ontology divides the functions of the e-commerce system and associated knowledge at a very low level, and thus it is especially useful in implementation. Components that operate in the user sphere interact with each other in a common domain, while components dealing with the environment sphere may be configured as a "wall" around the system. In addition, there are links between the spheres in the form of components whose working ontologies refer to portions of multiple spheres.

5.8 Dynamics of change

One of the most important considerations in managing knowledge in a near real-time environment such as an e-commerce system is time dependence. From this perspective an ontology may be defined which divides knowledge into constant, slowly-changing and fast-changing knowledge. This ontology may be correlated with the empirical-model-situational ontology, in identifying constant knowledge as empirical knowledge, slow-changing knowledge as model knowledge and situational knowledge as fast-changing knowledge. The correlation is not exact, of course. Fast-changing knowledge includes most knowledge derived from user interactions, but may describe knowledge which was, from the human perspective, identified as empirical. The time-dependency categorizations are very fuzzy, because situations may arise in which constant knowledge may require modification on the basis of fast-changing or slow-changing, model-type knowledge. Such a shift would describe the change in thinking before and after the large-scale development of the Internet as a commercial domain. The time-management functions of the system may be localized in an individual component that "watches" for changes and interruptions of this nature, or it may be integrated into each of the existing roles. The purpose of this ontology is to make the system "aware" of time and the dynamics of change in the knowledge feedback loop, so that the system does not get "stuck" or become outmoded.

5.9 Knowledge transfer (flow)

In addition to the established, role-attached perspectives on knowledge within the system, there is the view of knowledge as a transferable quantity. Here low-level knowledge is the modicum of exchange between knowledge entities.

"Knowledge transfer" is a view upon a view, an ontology of ontologies, which not only describes the existence of specific knowledge but also the knowledge that governs the interaction between users of that knowledge. In this way knowledge transfer overlooks the customer-supply ontology, the organizational ontology and others, as well as factors which are generally not considered when defining knowledge entities / "stationary" perspectives on the system:

- channels and mediums of knowledge transfer (electronic),
- possible barriers to knowledge exchange,
- the guaranteed delivery of knowledge to the people and / or components for whom it is intended,
- the demands and requests of knowledge entities within the system, and the acceptable and appropriate parameters for knowledge transfer,
- maps of knowledge and knowledge channels as well as schedules for the flow of knowledge within the system.

Though it is one of the primary functions of knowledge management, knowledge transfer plays a role in the system unlike knowledge creation or application, in that it is integrated with the system itself. In fact, the design of knowledge transfer is the design of the entire knowledge system, in which knowledge is created and applied. Here we consider knowledge transfer as a very high-level perspective on the knowledge in the system, a necessary set of relations for applying the low-level knowledge in a coherent way but one that is not especially concerned with the content of that knowledge.

6. KNOWLEDGE APPLICATION

Finally there is the process of knowledge application within the e-commerce environment. This process is the only one here described that directly supports the goals of the system. The creation of knowledge and the design of views upon it are the foundations for knowledge application. In order for this application to be successful (and thus for the e-commerce system to succeed in the market), the system must have the right knowledge in the right form to apply it. As has been previously established, any given ontology within the system may be reduced to its constituent knowledge; at its lowest level, this knowledge is a set of production rules which ultimate direct the actions of the system in responding to the many different situations it will encounter in the market.

Here we return again to the example of the user interface. For purposes of analysis, we start from the end product of the knowledge management processes: the display of items to the user. Let us suppose the user prefers items shown in list form, with no thumbnails or other images but one-line descriptions; this preference only applies to one type of item, such as coins, a type which the user is not particularly interested in the visual description above but prefers the information-intensive form of a text list. How does the system know to do this, when the default is to use thumbnails to display the coins, a few to a page?

Let us consider the variety of knowledge sources necessary for this application and thus a possible ontology for relating them. To start, the user interface component must have a basic knowledge of item types, including coins. These item types have different ways they may be displayed – some items may only be displayed in text, others with text and optional images, images with optional text and so on. In addition, the ontology must include/reference knowledge of the methods of display, which depend on the user's means of browsing the items (this is knowledge on the level of implementation). This leads to knowledge of the user's situation – not only how they are browsing the coins, but also what they want to see in browsing them. This knowledge can only be gained from analysis of user's past behavior, particular in relation to coins but also in other browsing situations. If the user has never before looked at coins, but has always chosen the text-only list format for display, then he will probably want to view listings of coin items in the same fashion (If… then = a knowledge statement, this one regarding a correlation between previous browsing habits and a choice the system should make). To further complicate the situation, the order and characteristics of the list should also be considered variable, subject to knowledge-produced system choices.

It is obvious that the user interface component must access a large subset of the system's knowledge in order to arrive at the display of coins in list format for this user. What is less obvious is how this actually occurs. The interface component is in fact divided into many different sub-components, each of which makes a particular sub-choice (such as the order of the list) and uses a sub-ontology to do this. The entire component (to identify it as more than its low-level

parts) need only consider the manipulation of these sub-components and the ontology, which includes the general concepts of user interfaces.

This idea extends to the entire domain of the e-commerce system. Very high-level ontologies, from the human or the component/subsystem/functional role perspective, should safely be able to manipulate high-level ontologies without violating the logical consistency of the constituent ontologies. This is very powerful in human hands, because it allows us to manipulate the knowledge of the system without removing ourselves from the low-level functioning of it.

7. KNOWLEDGE MANAGEMENT BASED ADAPTIVITY

One of the more important themes that permeate this paper is the fact that knowledge management is synonymous with change: adaptation and evolution. It is assumed that at the beginning the system operates on principles extracted from human experts that represent their view of the population of the potential customers. It also incorporates a number of theoretical laws that have been proposed as high-level abstractions of the economic reality. One of these theories claims that it is almost impossible to build a correct model of commerce (and therefore also e-commerce) reality based only on theory and knowledge extracted from human experts. The system has to be adjusted to the deal with real-life customers, who may behave differently than the theory predicted. In addition, as the time goes by, clients' interests and needs change due to their aging as well as due to the changes in the environment (e.g. bell bottom jeans were popular once). To be able to successfully work in the constantly changing world, the system has to be adaptive. Since knowledge management is a process of constantly adjusting knowledge through its application and through collection of additional data and extracting knowledge from it and incorporating it into the system, with the goal to constantly improve the existing model(s) of reality and effectiveness of the operation of the system, it **is** knowledge management that is the basis for system adaptivity.

8. CONCLUDING REMARKS

In this paper we have analyzed the knowledge management aspects of an e-commerce system, through the integration of knowledge functions with the realities and potential capabilities of e-commerce. To achieve this goal we gave discussed the three fundamental functions of knowledge management: knowledge acquisition, transfer and applications and showed how these functions become the basis of e-commerce system adaptivity. We have offered a number of perspectives on the knowledge in the system, as well as some possible positions from which this knowledge may be applied to both system-side and customer scenarios. Furthermore, these perspectives allow us to reconcile the many different views of e-commerce and knowledge in e-commerce, on the level of human analysis as well as that of implementation. Some of these views may be explicitly codified into ontologies and utilized in manipulating the knowledge and knowledge functions in the system. These ontology-perspectives allow the same low-level knowledge, gained from a variety of sources (such as human experts, data mining and automatic learning) to be approached in such a way that the necessary elements are related in a manner most useful for the task at hand.

The results of these theoretical investigations are currently being employed in the process of implementing a demonstrator system for e-travel support. The proposed system will be based on software agents and will follow the general decomposition proposed in [1]. The knowledge management processes described here and in [24] will become the keystone of the system. We will report on the progress of this implementation in the near future.

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